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CURRENT STATE OF THE DEVELOPMENT OF STAR LIGHT INERTIAL GUIDANCE TECHNOLOGY AND PERFORMANCE ANALYSIS

by

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CURRENT STATE OF THE DEVELOPMENT OF STAR LIGHT INERTIAL GUIDANCE TECHNOLOGY AND PERFORMANCE ANALYSIS

Fan Zhengwen

ABSTRACT Introduction is made of the realization of star light inertial guidance systems and the current status of the development of starlight inertial devices. Among these are included the development and applications of advanced star light sensing devices, quick connect star light inertial systems, and platform type star light inertial systems. In conjunction with this, a brief analysis is made of star light inertial system performance and applicable capabilities. At the same time, introduction is made of the places where quick connect systems and platform star light inertial systems are different. In conjunction with that, difficulties that are met with when option is made for the use of quick connect star light inertial systems are set out. Measurement principles associated with platform type star light inertial systems described in the article are capable, in the same way, of being used with quick connect star light inertial systems.

KEY TERMS Missile guidance Celestial body tracking guidance Inertial guidance

I. INTRODUCTION

Modern strategic ballistic missiles are in the midst of developing in the directions of maneuver, high precision, high reliability, rapid launch, strong defense penetration capabilities, and conversion to solid fuel. In particular, newer and more rigorous requirements are put forward with regard to guidance systems, spuring their constant progress forward.

At the present time, U.S. and Soviet strategic ballistic missiles have two types of guidance systems--full inertial guidance systems and star light inertial guidance systems. Full inertial guidance systems are independent type guidance systems. Due to the fact that the systems in question do not have auxilliary inertial guidance equipment, system errors, therefore, increase along with increases in flight time and range. For this reason--beginning in the early 1960's--the U.S. and Soviets began developing experimental star light inertial guidance systems. All were successful. In the 1970's, they were formally put into use. According to reports, the U.S. opted for the use of a single star design. In January 1977, MK5 star light inertial guidance tests were carried out for the first time. Success was achieved. After use on the Trident missile, precision was improved. In 1974, the Soviet Union opted for the first use on SS-N-8 missiles. Results were unclear. Later, tests were done on SS-N-18 missiles of more advanced new models of star light inertial systems. Precisions were increased. According to reports, the systems in question opted for the use of dual star designs. In recent years, the Soviet Union has also made use of star light inertial guidance systems on SS-N-20 missiles. Precisions have very greatly increased. However, they are still about one fold worse than the U.S. Facts prove that star light inertial guidance systems are certainly capable of improving missile guidance precision. The systems in question:

1. Have the capability for errors in initial calibration azimuths and positions;
2. Have the capability for rapid reaction;
3. Lower costs than full inertial guidance systems.

The drawbacks of the systems in question are, unfortunately, optical jamming. When the enemy carries out optical jamming or false artificial stars, single star designs can easily malfunction or introduce large errors. /180

In order to understand in depth star light inertial systems, this article uses the principles of platform type star light inetial systems as the foundation. It primarily introduces and discusses the realization processes associated with U.S. star light inertial systems, the current status of development, and technological characteristics. These principles of star light measurement, which this article discusses, are capable, in the same way, of application in quick connect star light inertial systems.

II. STAR LIGHT INERTIAL SYSTEM REALIZATION

1. Before Missile Launch

The first task before missile launch is to select the single star which is observed during flight. The reason is that the effects of star light calibration are primarily determined by star positions. Therefore, from previously compiled celestial star tables, this selected star must satisfy: (1) appropriate brightness; (2) position stability; and, (3) the ability to make system results reach maximum values. After star selection, calculation is done of star light weighting matrices (9x2 dimensional) in order to precisely determine how to use the two observed attitude errors in order to calibrate the 9 components of position, speed, and attitude. The last step associated with launch preparation processes is platform leveling adjustment and alignment. Speaking in terms of platform type star light inertial systems, it is nothing else than the level adjusted platform body which makes star light sensors align on the anticipated star.

2. Boost Phase

During boost phase flight, there is no clear distinction between star light inertial guidance realization and full inertial guidance systems.

3. Terminal Boost Phase

Terminal boost phase is the phase when star light sensors carry out star light alignment. In order to carry out star light alignment, spacecraft direction finding is first done. In conjunction with this, the spacecraft is rotated, making the star light sensor line of sight capable of pointing at the location of the anticipated star through the cardan casing and the special windows on the missile. It is only at this time that star light sensors are then capable of really carrying out measurement tasks, that is--on the basis of actual measurement results--multiplying by the precalculated weighting matrix to calculate out the 9 position, speed, and attitude components associated with calibration values. As far as this time is concerned, spacecraft are repositioned. In conjunction with this--in accordance with guidance rules--determined position and speed errors are controled and corrected. After that, terminal boost phase spacecraft begin to prepare to release reentry bodies.

4. Free Flight and Reentry Phase

In this phase, star light inertial guidance systems and full inertial guidance systems lack differences.

III. PROGRESS IN BASIC STAR LIGHT INERTIAL GUIDANCE SYSTEM DEVICES

1. Star Light Sensors

Star light sensors are key components in star light inertial

guidance systems. They are used in order to precisely determine the attitude of inertial components relative to the celestial body system. When star light sensors are being applied, they primarily act as a type of special narrow vision field camera. Star imagery is focused on the sensor device, and, by a combining of hardware and software comes to precisely determine star positions in the sensor device coordinate system.

In order to consider the entirety of device structures, star light sensors opt for the use of forms associated with the combined installation of inertial devices, as shown in Fig.1. The advantage is that, when star light sensor line of sight and inertial device coordinate systems are aligned, mechanical alignment errors can then be reduced to a minimum. (According to reports, the most rigorous alignment requirement is accelerometers.)

Star light sensor devices which star light sensors opt for the use of are photoconduction imagery tubes and solid state devices. Moreover, solid state devices are, at the present time, the most advanced star light sensor devices. They possess an array of imagery elements. In accordance with optical telescope optical axis lines, star light comes to be sensed and identified. The devices in question and photoconduction imagery tubing precisions associated with sensing stars are basically the same. The selection of the two types of devices basically depends on high or low cost and application capabilities under environmental conditions. In the selection of visual domains--with regard to star light inertial systems associated with astronavigational spacecraft--due to the fact that it is required to carry out star light detection in the daytime, in order to reduce as much as possible the influences of aerial backgrounds and to maintain a reasonable number of image elements, when selecting sensors, it is necessary to opt for the use of narrow visual domain star light/181

sensors.

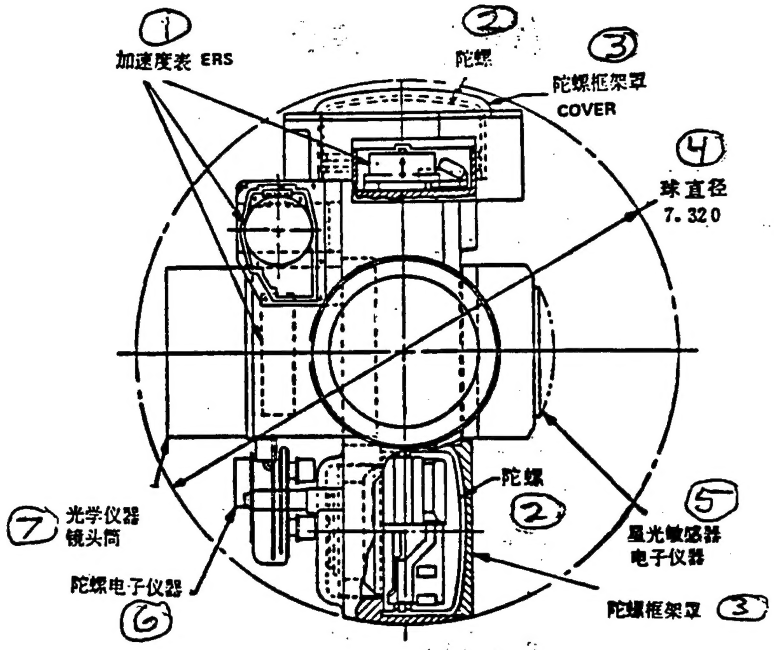

Fig.1 Typical Star Light Inertial Guidance System Composite Diagram

Key: (1) Accelerometer (2) Gyroscope (3) Gyroscope Framework Cover (4) Spherical Diameter (5) Star Light Sensor Electronic Instruments (6) Gyroscope Electronic Instruments (7) Optical Instrument Lens Tube

2. Star Light Inertial Platforms

As is widely known, platform type star light inertial guidance system star light sensor devices must be installed on the composite cardan structure. Only when missiles are in flight is it then possible to make star light sensor device optical axses aim at the preselected celestial body on the basis of the two degrees of freedom associated with altitude and azimuth. In order to select appropriate and effective celestial bodies, the entire platform assembly needs an optical window and cardan degrees of freedom appropriate to aerial visual domains. A 95° visual domain is appropriate. Moreover, it is possible to realize.

At the present time, among star light inertial navigation and guidance systems, option is made for the use of multiple frame composite platform systems--for example, the U.S. Trident missile

only opted for the use of a four frame platform system. On the basis of reports, in recent years, five frame starlight platform inertial guidance systems and two frame star light platform inertial guidance systems were also developed.

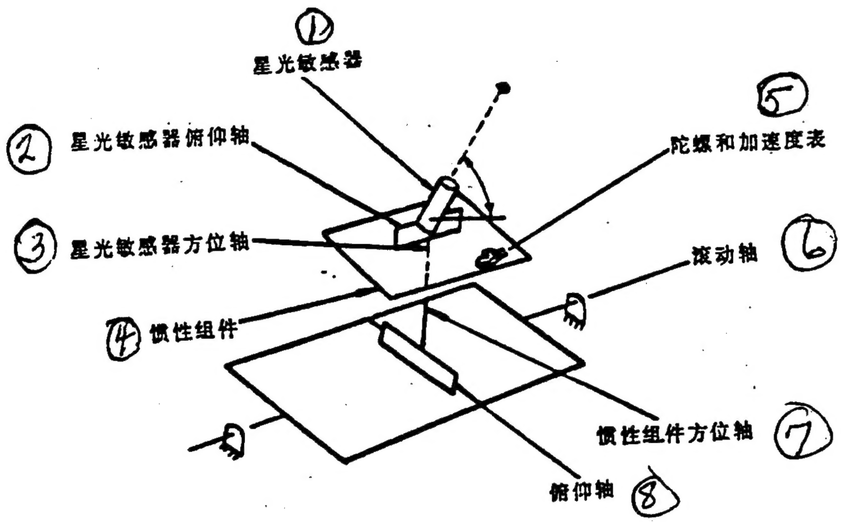

Fig.2 Five Frame Star Light Inertial Platform Assembly Schematic Diagram

Key: (1) Star Light Sensor (2) Star Light Sensor Pitch Axis (3) Star Light Sensor Azimuth Axis (4) Inertial Assembly (5) Gyroscope and Accelerometer (6) Roll Axis (7) Inertial Assembly Azimuth Axis (8) Pitch Axis /182

The structural forms of five frame star light platform inertial guidance systems are the installation on three frame inertial platform assemblies of a subassembly containing two frames of star light sensors as shown in Fig.2. This type of platform system--speaking in terms of technology--is advanced. Due to the fact that it opts for the use of isolated gyroscopes, the performance is better than quick connect type inertial gyroscope platform systems. However, the whole system is rather complicated.

The form of installation associated with two frame star light inertial guidance systems is taking quick connect inertial guidance systems and installing them on two frame telescope assemblies. The azimuth and pitch attitudes of telescopes can be calculated, and, in conjunction with this, it is possible to control them. Similar to this type of two frame star light inertial system--in the test phase of the Assault Breaker missile project--this was verified on the T-16 test missile. These types of principles and methods can be used on astronavigational spacecraft. This type of inertial system--when carrying out position and speed calculations--is, in

actuality, equivalent to a quick connect inertial system. See Fig.'s 3 and 4. Carrier vehicle attitudes are determined by relying on integrated data from inertial systems and frame sensors.

Two frame star light inertial platform systems possess the advantages below.

(1) Functions are the same as five frame platform systems.
(2) Star light inertial platforms are simple.
(3) They are small in volume and light weight.
(4) With regard to multiple star detection, quick connect type gyroscopes permit star light sensors to rapidly return to position.

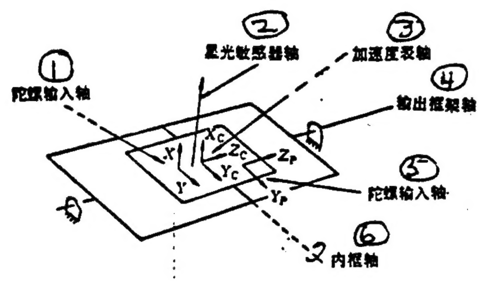

Fig.3 Two Frame Star Light Inertial Measurment System Schematic

Key: (1) Gyroscope Input Axis (2) Star Light Sensor Axis (3) Accelerometer Axis (4) Output Frame Axis (5) Gyroscope Input Axis (6) Interior Frame Axis

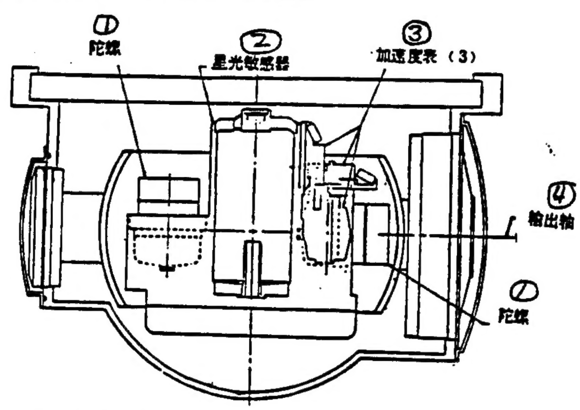

Fig.4 Star Light Inertial Measurement System Cardan Structure Schematic

Key: (1) Gyroscope (2) Star Light Sensor (3) Accelerometer (4) Output Axis

Drawback: Under conditions where the same type of gyroscope is used, two frame quick connect installed gyroscope performance is lower than five frame isolated gyroscope installations.

3. Quick Connect Star Light Inertial Guidance System Applications

In a quick connect system, inertial coordinate systems are dependent on computer software maintenance. Moreover, they are not reliant on their own components for maintenance. As a result, in inertial space, it is necessary to provide an observable attitude error. This is necessarily dependent on the carrying out of computer processing. According to reports, the basic principles of platform type star light inertial guidance systems are also capable of being used on quick connect star light inertial guidance systems. The main difference between them lies in the measurement of their own realization. Due to the fact that--during measurement periods--star light sensor lines of sight must be stable in inertial space, star light sensors are only then able to carry out observation tasks. Speaking in terms of platform systems, star light sensor line of sight stability is primarily dependent on composite platform systems. However, quick connect systems /183 opt for the selection of several different methods in order to stabilize star light sensor lines of sight. They are primarily dependent on precision control of spacecraft movements or adjusting degrees of freedom permissible for adjustment within quick connect composite system finite ranges. If these problems are capable of very good solutions, then, measurements are carried out in platform star light inertial guidance systems and quick connect star light inertia guidance systems. In essence, there is no difference.

IV. STAR LIGHT INERTIAL GUIDANCE SYSTEM CHARACTERISTIC ANALYSIS

1. Star Light Calibration Characteristics

In order to understand even better characteristics in weapons systems after option is made for the use of star light calibration, the several typical error sources below are used as examples. A brief analysis is made with regard to star light calibration influences.

(1) Assuming that system error sources only have 100 arc seconds of initial azimuth error, speaking in terms of standard trajectories, this error will make weapons miss targets by 3048m. If one opts for the use of star light calibration, the angle of elevation of the selected star relative to the launch plane is 60°, that is, 100 arc seconds of initial azimuth error will produce a measurment attitude capable of observations of 50 arc seconds (100xcos60°). Due to the fact that this system only has azimuth error, with regard to each arc second of observed attitude error, laterally, it is possible to calibrate 60.96m (called the weighting coefficient). Therefore, after star light calibration, the target miss amount which weapons systems bring with them due to initial

azimuth error is zero. See Table 1.

(2) Assuming the system only has 0.25°/hour azimuth gyroscope drift, the analysis method is the same as (1). Calibration results are as seen in Table 1.

Table 1 Error Propogation Comparisons

(1) 误差源	(2) 全惯性脱靶量(m)	(3) 可观测的星光测量姿态(角秒)	(4) 加权系数(m/角秒)	(5) 星光校正脱靶量(m)
(6) 100角秒初始方位误差	3048	50	60.96 (54.86)	0 (304.8)
(7) 0.25°/小时陀螺漂移	762	25	30.48 (54.86)	0 (−609.6)

Key: (1) Error Source (2) Full Inertial Target Miss Amount (3) Observed Star Light Measurement Attitude (Arc Seconds) (4) Weighting Coefficient (m/Arc Second) (5) Star Light Calibration Target Miss Amount (6) 100 Arc Second Initial Azimuth Error (7) 0.25°/Hour Gyroscope Drift

(3) Consideration is given at the same time to two types of errors. Due to the fact that the systems in question are multiple error source systems, ideal system weighting coefficients are generally not able to be calculated out before the fact. It is only possible to make use of statistical methods to calculate optimum weighting coefficients. From Table 1, it is possible to know that 100 arc second initial azimuth errors will cause full inertial guidance systems to miss targets by 3048m. If use is made of star light calibration, the observed attitude is 50 arc seconds.

Making use of an optimum weighting coefficient of 54.86m/arc second, the star light error miss amount is then 304.8m (See the data in parentheses in Table 1). In a similar way, if one is concerned with 0.25°/hour gyroscope drift error--opting in the same way for the use of 54.86m/arec second optimum weighting coefficients, then, star light inertial target miss amount is -609.6 meters. As a result, weapons system overall target miss amount is calculated in accordance with square roots of square sums to be $\sqrt{304.8^2 + (-609.6)^2}$ = 672m. If option is not made

for the use of star light calibration, then full inertial system overall target miss amount is $\sqrt{3048^2+762^2}$ = 3093m. From this, it can be seen that, after option is made for the use of star light calibration, weapons system target miss amounts are only 21.7% of full inertial system overall target miss amounts.

(4) Selection is made of an equilibrium predicted value using platform systems in order to represent the performance of weapons systems. In conjunction with this, 1000 unit circular error probabilities (CEP) associated with (illegible) calibration are given arbitrarily. As far as analyses of various CEP subsystem influences are concerned, see Table 2. Table 2 respectively sets out various primary subsystem circular error probability errors and overall circular probability errors associated with star light inerital systems and full inertial systems. From Table 2, it is possible to see that, after gyroscope and other guidance (including azimuth error) subsystems opt for the use of star light calibration, results are the best. Moreover, accelerometers and geophysical factors as well as geodetic error subsystems are only subject to tiny influences. In particular, reentry and subwarhead deployment subsystems are completely uninfluenced. After the /184 entire weapons system opts for the use of star light calibration, circular error probabilities are reduced 14.3%.

Table 2 Subsystem Characteristics

(1) 分系统	(2) 全惯性CEP(单位值)	(3) 星光惯性CEP(单位值)
(4) 加速度表	464	482
(5) 陀螺	469	95
(6) 星光敏感器	0	236
(7) 其它制导	451	299
(8) 地球物理因素和大地测量误差	342	339
(9) 再入和部署	383	383
(10) 整个系统	1000	857

Key: (1) Subsystem (2) Full Inertial CEP (Unit Value) (3) Star Light Inertial CEP (Unit Value) (4) Accelerometer (5) Gyroscope (6) Star Light Sensor (7) Other Guidance (8) Geophysical Factors and Geodetic Errors (9) Reentry and Deployment (10) Entire System

2. Silo Launch Characteristics

Above, it has already been demonstrated that, as far as opting for the use of star light inertial guidance systems with regard to 1000 unit CEP silo launched weapons systems is concerned, it is possible to reduce system CEP 14.3%. Obviously, this is very significant. However, speaking in terms of silo launched weapons systems, making use of star light inertial guidance's greatest advantage is lowering the initial direction finding error, increasing weapons system precision. Fig.5 shows the relationships between system CEP and initial direction finding errors. From Fig.5, it is possible to know that, making use of star light inertial guidance, even if initial dir ction finding errors increase, CEP influences on systems are still very small. Speaking in terms of full inertial systems, if initial direction finding errors increase, system precision will very rapidly drop. Due to this, it is possible to know that, after opting for the use of star light inertial guidance, precision is not only improved. Requirements with regard to gyroscope drift are relaxed.

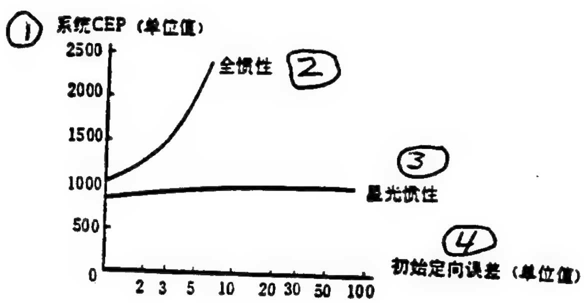

Fig.5 Relationships Between System CEP and Initial Direction Finding Error

Key: (1) System CEP (Unit Value) (2) Full Inertial (3) Star Light Inertial (4) Initial Direction Finding Error (Unit Value)

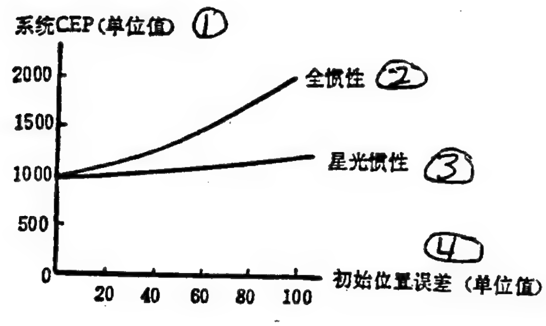

Fig.6 Relationships Between System CEP and Initial Position Error

Key: (1) System CEP (Unit Value) (2) Full Inertial (3) Star Light Inertial (4) Initial Position Error

3. Maneuver Launch

The most obvious problem with maneuver launches is that the launch point is not precisely determined. Due to the fact that launch points are not precisely determined, launch latitude and longitude errors do not represent translation errors but are errors associated with rotation around the earth. After opting for the use of star light calibration, star light sensors are then capable of making this type of error drop to minimum values. Therefore, star light sensors then clearly show their superiority with respect to maneuver launch methods associated with relatively large inital position errors.

As far as silo launches discussed above are concerned, after opting for the use of star light inertial systems, initial longitude and latitude error sensitivities are roughly 1/3 of the full inertial systems. As a result, these errors need only increase and, following that, weighting matrices are changed in order to strengthen corrections of these error sources, making /185

sensitivities correspondingly become even smaller, as shown in Fig.6 . Fig.6 shows the functional relationships associated with full inertial systems and star light inertial system CEP as well as initial position errors. The assumed conditions associated with these functional relationships are: (1) latitude and longitude values associated with star light inertial guidance systems and full inertial guidance systems are equal to each other; (2) initial missile direction finding errors associated with opting for the use of star light inertial systems are large.

V. STAR LIGHT INERTIAL GUIDANCE SYSTEM APPLICATION CAPABILITIES

1. Rapid Reaction Capabilities

With respect to star light inertial system rapid reaction capabilities, they primarily refer to reaction capabilities associated with the calibration of initial azimuth alignment errors. One system maintains operations at normal temperatures. If semidormant full inertial system reactions are a few hours, then, semidormant star light inertial system reaction times are roughly only 15 minutes. Besides this, speaking in terms of azimuth calibration before launch, calibration precision requirements are relaxed approximately 100 fold compared to full inertial systems.

Due to the fact that star light inertial systems possess this type of rapid response capability, prior to launches, therefore, star light inertial systems are fully capable of being in full dormant or semidormant configurations. According to reports, at the present time, in cases where rapid response requirements are satisfied, star light inertia system full dormant operational configurations are clearly a type of design which is capable of being selected in association with survivability. This type of design possesses the three advantages below.

(1) Reduces equipment maintenance and spare equipment.

(2) Lowers power consumption. This point is of particular significance in systems possessing strict power limitations. If a system consumes 300 watts of power--figuring according to 50 kilowatts required for each week--in a three month independent maneuver deployment method, operating system energy storage then becomes a problem.

(3) Full dormant configuration life time costs are lower than full operational configurations. The primary reason is that unit malfunction occurence rates associated with low operating period systems are obviously lower than unit malfunction occurence rates associated with continuous operation systems.

2. Performance in Hostile Environments

As far as the performance of star light inertial systems in hostile environments are concerned, it is primarily a capability for practical use in the study of star light sensor devices under nuclear radiation conditions. That is,

(1) star light devices have the capability to undergo large doses of radiation;

(2) star light devices have the capability to operate through residual radiation.

Star light sensor devices are capable of sensing secondary radiation. As far as the devices are concerned, their sensitivity to radiation and the size of radiation doses which they can survive is determined by two factors:

(1) device operation levels under saturation configurations (capable);

(2) overall attenuation status associated with amounts of noise produced in star light sensors and signal-noise in instruments.

Speaking in terms of each sensor device, if the observed radiating surface is higher than the expected radiating surface, star light sensors must delay star light measurements right on until radiating surfaces rapidly attenuate to levels that star light sensor devices are capable of receiving. Only then is it possible to carry out star light measurements. Star light sensors associated with photoconducting imagery tubing have already been proven in this area. Their sensitivity is clearly lower than the sensitivity of solid state star light sensors at the present time. However, during periods of relatively high secondary radiation, operations are entirely possible. According to reports, solid state star light sensors the development of which is just now in the process of being carried out are capable of enduring large amounts of nuclear radiation. The harm is not great. They are a type of device with survivability.

VI. A FEW OPINIONS

1. In strategic weapons systems--in particular, in underground missiles and land based mobile missile weapons systems--there are a great many ways to improve weapons system precisions. Looked at in terms of the present, opting for the use of star light inerital guidance systems is one advanced design that is indispensable. /186

2. In a weapons system which opts for the use of star light inertial guidance technology, the precisions of various subsystems are correspondingly raised--in particular, the precisions of accelerometers, gyroscopes, and other guidance are increased. It is possible to make weapons system accuracies go up further. From Table 2, it is possible to know that--after opting for the use of star light calibration--changes associated with accelerometer precision are not great. However, accelerometer precision distribution values account for a comparatively large proportion among precision distribution values associated with systems as a whole. Therefore, influences are relatively large with regard to overall weapons system accuracy. As a result, it is only necessary to improve accelerometer performance to increase the precision. It is then possible to very, very greatly raise overall weapons system accuracy.

Besides this, from Table 2, it is possible to see that--after opting for the use of star light calibration--the precisions associated with gyroscopes and other guidance are clearly increased. The results are the best. As a result, among weapons systems which opt for the use of star light calibration, the precisions associated with gyroscopes and other guidance are raised at the same time. In the same way, it is possible to make precisions associated with overall weapons systems achieve improvements. The U.S. has made new progress in the area of increasing gyroscope precisions, developing various types of high

precision velocity gyroscopes--for example, flexible gyroscopes, dynamic pressure gyroscopes, laser gyroscopes, and so on. Moreover, improvements have been carried out on currently existing gyroscopes. For example, the U.S. has carried out improvements on Trident missile gyroscopes opting for the use of interference tuning. For the most part, a number of detailed alterations were done with regard to the design of certain key components. Besides that, improvements were also made in such areas as materials interchangability and critical parameter control. In gyroscopes, liquid floating bearings replaced ball bearings. Later, liquid floating gyroscopes were also changed to dynamically tuned flexible gyroscopes. In other guidance components, three frame platforms were changed to four frame platforms. From this it can be seen that, after option is made for the use of star light inertial guidance systems, there is a need to make system precisions increase even further. There is also a need to improve what currently exists and to develop new models of instrumentation, components, and platforms--improving without let up in the areas of design, manufacture, assembly, and test meausrement.

3. With regard to applications of platform type star light inertial guidance systems and quick connect star light inertia guidance systems--looked at from what currently exists--the selection of the two systems depends primarily on technological development levels and realization capabilities associated with various subsystem instruments and devices as well as computers. Due to the fact that, as far as star light sensor measurement time periods are concerned, the lines of sight must be stable in inertial space, this is relatively easy to realize with regard to platform systems. However, quick connect systems must opt for the use of other methods in order to be realized. At the present time, use is primarily made of advanced attitude control systems in order to do the realization. In terms of computational methods, use is made of four element matrices to take observed errors in missile fuselage coordinate systems through calculation processing. After that, they are converted to inertial coordinate systems. This type of method--to look at it--seems to be relatively easy. However, in realization, it is comparatively difficult. In addition, quick connect guidance systems and missile bodies move together. The dynamic errors are relatively great. Precisions are very difficult to guarantee. Speaking in terms of the development of star light inertial guidance systems by the U.S. at the present time, option is made for the use of platform type star light inertial guidance systems which are relatively easy to realize. For example, five frame, four frame, and two frame platform star light inertial guidance systems have already attained practical applications. In particular, as far as two frame platform systems are concerned, when carrying out position and speed calculations, in actuality, they are equivalent to a quick connect inertial guidance system.

4. Relevent Selection Problems Associated with Single Star Designs and Dual Star Designs. At the present time, selections associated with these two types of designs are primarily determined by weapons system application environments, technological

conditions, and strategic and tactical performance. Single star designs are only capable of applications to missiles so long as they have a precisely known maximum error. Moreover, use is made of them under conditions where gyroscope and platform performance is good. The advantage is that they are simple and easy to carry out. It is possible to make a good initial selection of the star light. The biggest drawback is the fear of optical interference. There are definite limitations during use. With regard to dual star designs, they are primarily applicable for use under conditions where gyroscope and platform drift are relatively large, and it is not possible before the fact to calculate precise amounts for errors or there are two or more comparatively large error quantities. The advantage is that--before launch--it is possible to do rough positioning and launch rapidly. They are capable of use in the separate guidance of multiple warheads. Compared to single star designs, they are more able to resist hostile optical jamming. However, the structure of dual star designs is complicated. Technical requirements are high. Seen from the view of development, option being made for the use of dual star designs fits better with realities. They are definitely able to improve missile precision, and, in conjunction with that, they have relatively large tactical and strategic value.

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